

Digital Design and Computer Architecture

Lab 1: AND Gate [IN-LAB ASSIGNMENT]

0. Introduction

Total points assigned to ALL lab 1 assignments- 10 points

In this lab you will design a simple AND gate on Quartus. Along the way, you will learn how to use the Altera field-programmable gate array (FPGA) tools to enter a schematic, simulate your design, and download your design onto a chip.

After completing the lab, you are required to turn in something from each part, as a lab report. Refer to the “What to Turn In” section at the end of this handout before beginning the lab. Refer to the “What to Turn In” section at the end of every handout to check what are the submission requirements for each prelab assignment or in-lab assignment.

If you haven’t already done so, go through the Lab 1 Prelab assignment and read all three instruction sets.

1. Design Implementation

After having read instruction set 1, you will be able to login to one of the ECE lab PCs. Once you have logged into a system that works, follow instruction set 2 to create your first Quartus Project.

1. Once you have created a new project, go ahead and open a new file for Block Diagram design.
2. In this file, pick the AND logic gate from the library of available gates and place it on the canvas.
3. Next pick an input port and place one for each of the two input ports of the AND gate. Also place an output port for the output from the AND gate.
4. Once you have placed all the ports and gates on the canvas, go ahead and save your design.
5. After saving your design, you need to compile your design.

2. Simulation

After making sure that your design compiles successfully, you now need to prepare a simulation to verify the working of your design.

1. First, you need to create a new file and select **University Program VWF** option.
2. Import all the input and output nodes from your design to the simulation waveform editor. Then edit the input waveforms so that all possible input combinations are covered.
3. Once you are satisfied with your input waveform design, run the simulation waveforms to see the output waveform.
4. Verify that the output performs as expected.
5. Once you are satisfied with the output, take a screenshot of all the waveforms in the waveform editor with the input waveforms at the top and the output waveforms at the bottom. **This screenshot needs to be included in your report.**

3. Terasic Board Implementation

Now that you have verified your design through simulation, the next step is to verify your design on the Terasic board. For this you will be using instruction set 3 along with the Terasic Board user manual.

1. The third instruction set will help you complete this part of the lab assignment. You will also need to know which hardware on the board to use and their corresponding pin location
2. Like always, refer to the user manual for the Terasic board to find which pins you need to use. For this lab, you can use-
 - Any of the 18 slider switches for input to the AND gate. You can find the information about how the slider switches work in section 4.2 on printed page 32 of the Terasic board instruction manual on Canvas. Pin locations for the slider switches can be found in Table 4-1 on printed page 35 in the manual.
 - Any of the red LEDs or the green LEDs for the output of the AND gate. You can find information about Using the LEDs in section 4.3 on printed page 34 of the manual. Pin locations for these can be found in Table 4-3 on the printed page 35.
3. Once you have successfully downloaded your design to the Terasic board, verify that your design works as expected. Try all possible input combinations and check the output.
4. Once you have verified your design on the board, have the lab instructor verify it as well. This verification counts as assessment for each lab.
5. Click a picture of the board for each possible input combination alongwith the output. You need to include these pictures in your lab report.
6. Congratulations! You have successfully completed Lab 1.

4. What to Turn In

Due Date- One week from when the experiment is performed (that is the week of September 19)

Points assigned to Inlab Assignment- 10 points for Lab 1 come from in-lab assignment report submission

You must submit an electronic copy of the following items via Canvas. Submit to the Lab 1 In-lab Assignment. These should all be included in a single “pdf” file. Be sure to label each section and organize them in the following order. Messy or disorganized labs will lose points.

1. Please use ECE Lab Report Cover Page (can be found in the Files Tab on canvas).
2. Please indicate how many hours you spent on this lab. This will be helpful for calibrating the workload for the upcoming Lab assignments.
3. Include the following figures:
 - Your completed schematic (that is the block design). This can be produced using the **File→Export** feature in the Schematic Editor (you may need to select .bmp format). You can also take a screenshot if this option seems difficult for you.
 - Your simulation result of the experiment which includes all input waveforms and the output waveforms. This can again be produced using the **File→Export→Image...** feature of the ModelSim Simulator. Again, you may take a screenshot if this seems difficult.
4. Include pictures of the code running properly on the board.

Some Quartus Tips

- Make sure you don't have any spaces in any of your folder or file names.
- Some CAD tools are case sensitive and others are case insensitive. Never use two different capitalizations of the same signal because some tools may treat them as different signals while others may treat them as the same signal. The easiest solution is to be consistent in your choice of capitalization.

Some Terasic Tips

- If downloading the code to the board fails for unexplained reasons, try unplugging the board from the USB and repeating the entire process.
- Some slider switches or LEDs or push buttons might be faulty on your Terasic board and therefore may not work as expected. DO NOT handle the board in a rough manner to debug this issue. This will only damage the board further.
- Instead, try using another slider switch or LED or push button. If the problem persists, your design may be at fault.